Industrial Materials for the Future (IMF) R&D Priorities*

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Objectives of the Study

- **Identify materials research needs to meet the goals and objectives of the Industries of the Future and that are consistent with the mission of the IMF program.**

- **Describe materials performance goals and challenges and the benefits to the Industries of the Future.**

- **Prioritize IMF materials research activities to achieve the performance goals and benefits.**

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Industrial Materials for the Future Mission

- **Research, design, develop, engineer, and test new and improved materials, as well as more profitable uses of existing materials.**

- **Focus is on longer-range needs of Industries of the Future.**

- **Does NOT fund mature materials technologies that compete for OIT industry team funds.**

Classes of Materials with Suites of Properties Beyond Capabilities of Commercial Materials

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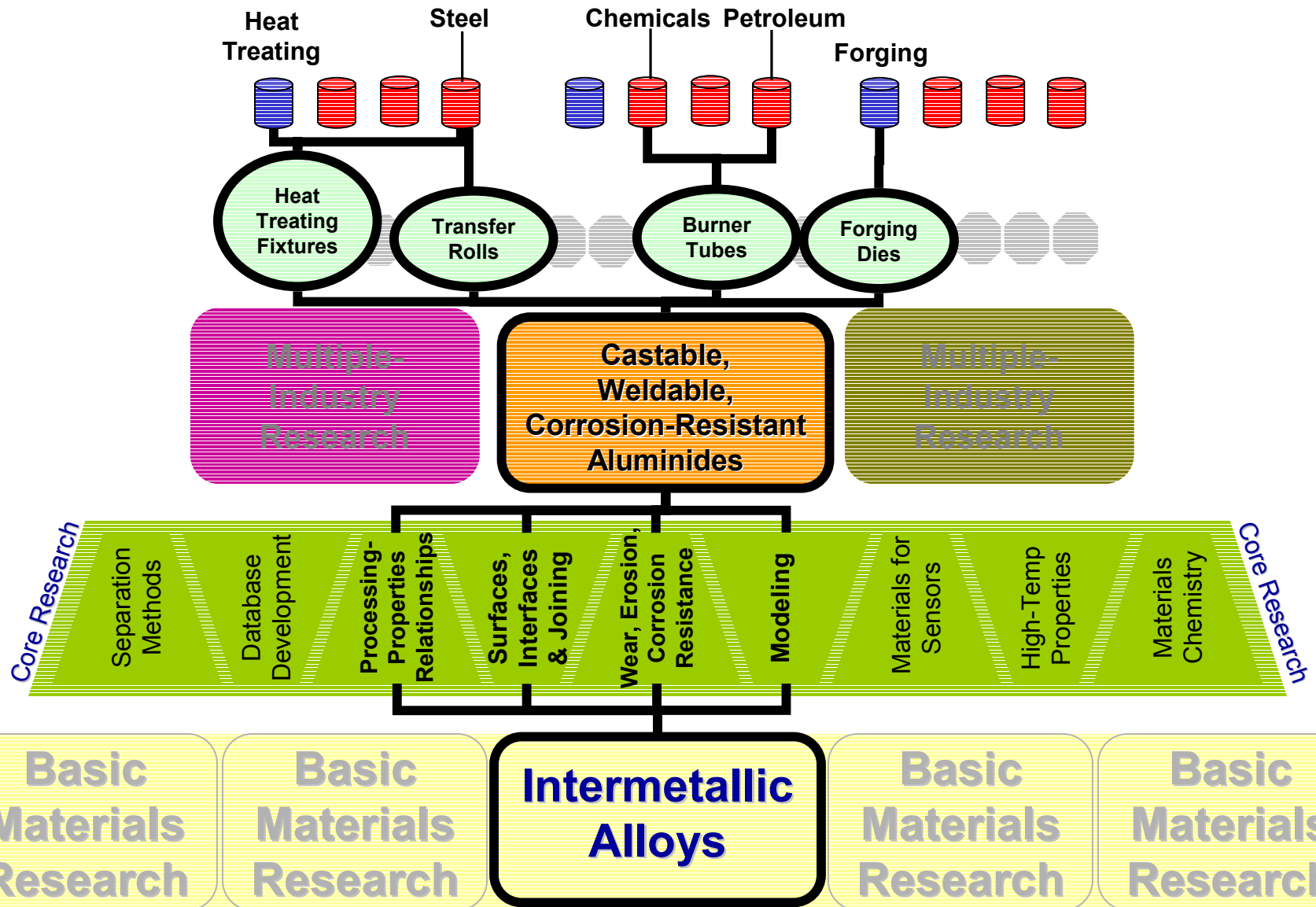
Schematic View of IMF Research

Supporting-industry R&D

OIT industry team R&D

IMF Multiple-Industry R&D
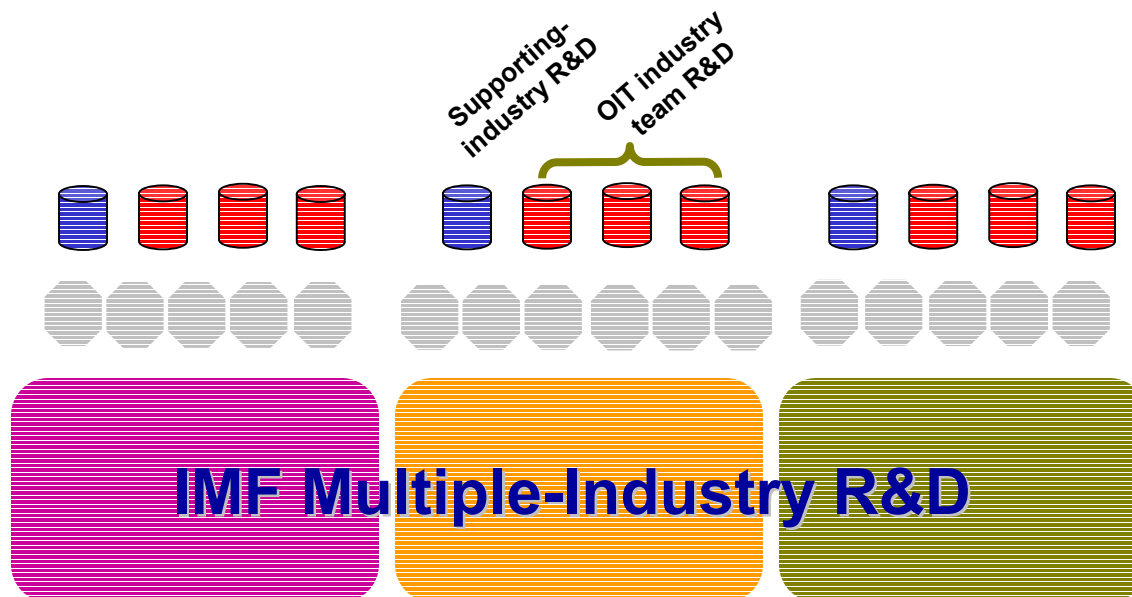
IMF Core Research

Basic Materials Research
DOE Office of Science, NSF, ONR, etc.

Matrix-Building Methodology

- **High-priority R&D needs and performance targets taken from Industries of the Future roadmaps**
    - Additional input from NMAB report on materials needs for Industries of the Future
    - R&D designated as near, mid, or long term when so defined in roadmap

- **Office of Science, IMF, and OIT industry teams' R&D projects placed**
    - According to relevance to R&D needs, performance targets, or both
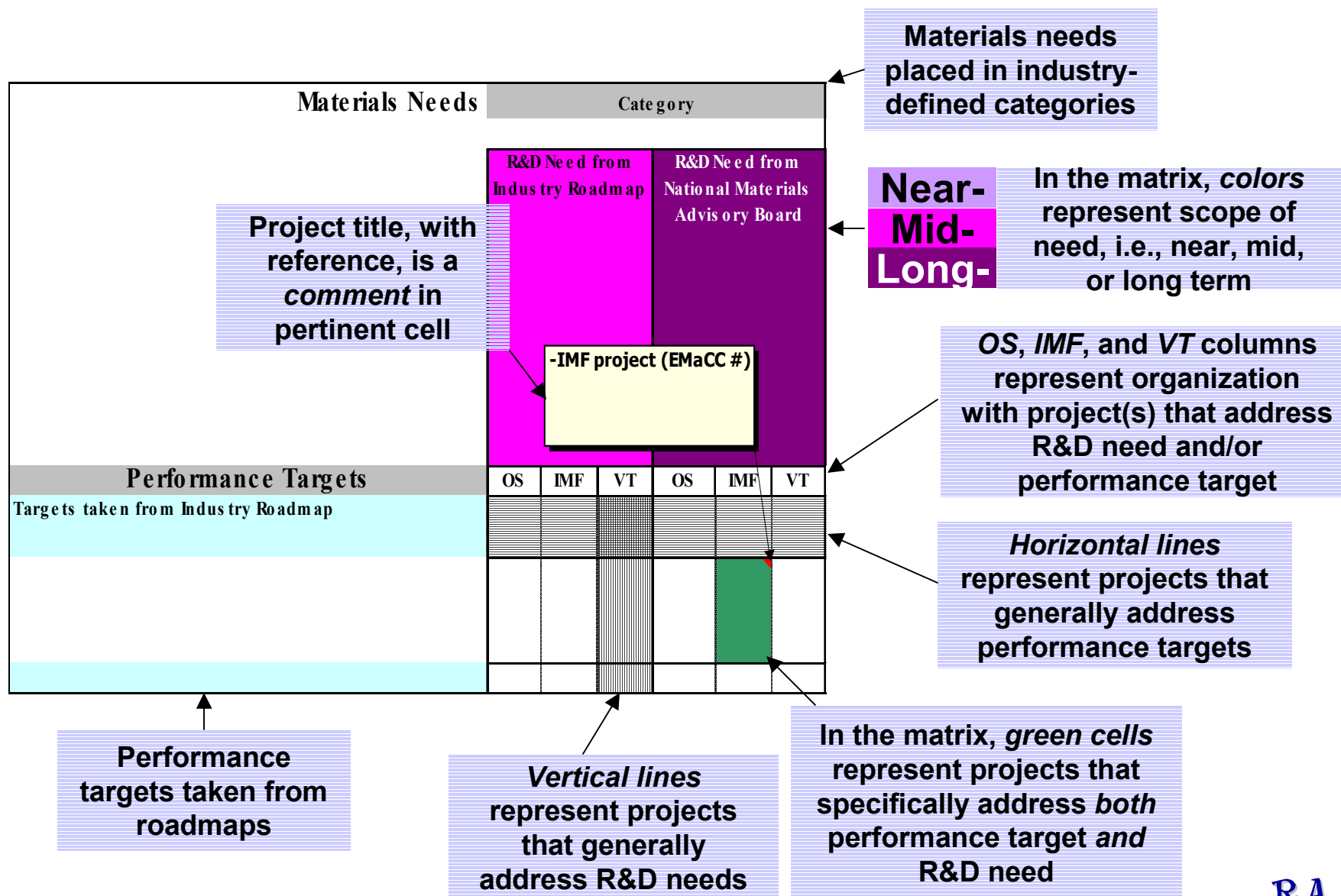
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High-Priority R&D Needs

	High-Priority Needs in Roadmap	High-Priority *Materials* Needs in Roadmap	Needs in Matrix*	Needs in Matrix that Fit IMF Mission	Core Research Priorities	Multiple-Industry Research Priorities
Aluminum	27	22	23	11	9	5
Glass	30	23	31	18	10	4
Steel	N/A**	N/A**	30	13	8	6
Metal casting	24	19	27	9	9	7
Chemicals	41	27	33	17	10	6
Petroleum	44	30	36	13	8	4
Forest products	37	14	39	10	10	7
Agriculture	52	7	28	6	5	2
Mining	N/A**	N/A**	30	13	6	4

*Up to 3 needs added from NMAB report per industry.
**High-priority needs not identified by steel and mining industries.

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Matrix Building

imf — *Industrial Materials for the Future*

Materials needs placed in industry-defined categories

In the matrix, *colors* represent scope of need, i.e., near, mid, or long term

Near-
Mid-
Long-

Project title, with reference, is a *comment* in pertinent cell

OS, *IMF*, and *VT* columns represent organization with project(s) that address R&D need and/or performance target

Horizontal lines represent projects that generally address performance targets

Performance targets taken from roadmaps

Vertical lines represent projects that generally address R&D needs

In the matrix, *green cells* represent projects that specifically address *both* performance target *and* R&D need

Materials Needs	Category					
	R&D Need from Industry Roadmap			R&D Need from National Materials Advisory Board		
			-IMF project (EMaCC #)			
Performance Targets	OS	IMF	VT	OS	IMF	VT
Targets taken from Industry Roadmap						

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Aluminum R&D Priorities

ALUMINUM

Refractories

Develop more durable refractory materials (NMAB)

OS	IMF	VT

Work being done in OS and IMF, but not being transferred to VT

Casting

Casting					
Low-cost inclusion meter: -100% metal inspection -<10 micron limit -in line -real time -operator friendly -continuous	Develop better tool and die materials with improved heat-extraction capabilities (NMAB)	Develop a non-contact sensor and method to ID	Fundamental info. on solidification of alloys to predict	Develop means for removing specific impurities from the melt g., Mg, Fe, Pb, Li, Si, Ti	Develop high-capacity "furnace" design for the future -safe and enviro-friendly -minimize melt loss -improve melt rates -fuel efficient -cost effective

Large area of research needing further work

Modeling

Fundamental info. on solidification of alloys to predict microstructure surface properties and stresses and strains:
-computer model capable of process control in real time

OS	IMF	VT

Broad area with many applications

Joining and Welding

Eliminate pretreatment for joining
-bonding
-spot welding
Non-mech joining methods for non-weldable alloys

OS	IMF	VT

Work being done in OS and IMF, but not yet transferred to VT

Advanced Forming

Advanced forming and net-shape/near net-shape technology
-semi-solid casting
-casting spray-forming
-spray forming
-physical vapor deposition
-PM technology
-rapid solidification

OS	IMF	VT

Broad area with promising initiatives

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Aluminum R&D Priorities

ALUMINUM

High Caustic

Tool &Die Materials

Develop materials and processes to allow operation of Bayer process at high caustic concentrations (NMAB)

OS	IMF	VT

Develop better tool and die materials with improved heat-extraction capabilities (NMAB)

OS	IMF	VT

Products
Microstructure Properties

No work being done

Rolling and Extrusion

Work not yet transferred to VT

Understand relationship of aluminum alloy composition & processing & its effect on microstructure and properties
-zero earring, high strength formability can sheet product
-develop 3000 series alloys for end stock beverage

OS	IMF	VT

No work being done

Rolling and Extrusion														
Develop better understanding of the factors affecting metal flow in hollow extrusion dies			Understand relative strength and formability of alloys as functions of: -hot rolling -structure -cold rolling -reduction sequence -thermal history			Complete formability studies of strain, strain rate, and temperature on the state of stress			Develop techniques to determine sheet formability characteristics and associated test methods			Enhance surface quality in strip and slab cast alloys		
OS	IMF	VT	OS	IMF	VT	OS	IMF	VT	OS	IMF	VT	OS	IMF	VT

No work being done

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Aluminum R&D Priorities

- High-temperature materials, including refractories

- Casting

- Advanced forming

- Tool and die materials

- Databases and modeling

- Joining and welding

- *Materials for highly caustic environments*

- *Rolling and extrusion*

- *Products and microstructure processing*

NOTE: As of this writing, IMF is addressing the areas in plain type but not those in italics.

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Summary of R&D Priorities

Aluminum
- High-temperature materials, including refractories
- Casting
- Advanced forming
- Tool and die materials
- Databases and modeling
- Joining and welding
- *Materials for highly caustic environments*
- *Rolling and extrusion*
- *Products and microstructure processing*

Glass
- High-temperature materials database
- Robust nonrefractory materials
- Hot glass contact materials
- Improved refractories
- Improved heat-recovery materials
- Coatings
- *Multiple sensor needs*
- *Glass melting and forming models*
- *Surface and interface properties*
- *Use of microwaves and ultrasonic means of controlling Glass Shape*

Steel
- Wear-resistant materials
- High-temperature materials and refractories
- Coating properties, processing, and applications
- Tooling
- Joining
- Process modeling
- *Refractory repair (cokemaking)*
- *Energy-saving processes*

Metal Casting
- Computer design tools
- Mold and die fill modeling
- Casting (properties, microstructure, and processing)
- Dies and coatings
- Refractories
- Reduced emissions
- Joining of new alloys
- *Testing standards*
- *Waste stream treatment, recycling, and use*

Chemicals
- Ceramic and composite reliability and performance data
- High-temperature materials, including refractories
- Erosion- and corrosion-resistant materials and coatings
- Materials for separations
- Joining, including oxide dispersion strengthened (ODS) superalloys
- *Thermophysical, kinetic, and mechanical materials data*
- *Stress-corrosion cracking of construction materials*
- *NDE for fracture toughness*
- *Surface chemistry modeling*
- *Composition-corrosion relationships for carbon steel*

Petroleum
- Membranes
- Catalysts
- *Combustion and yield modeling*
- *Fouling-resistant materials and coatings*
- *Computational catalyst design*
- *NDE and inspection*
- *Corrosion monitoring*
- *In situ residual stress measurement*

Forest products
- Separation technologies
- High-temperature materials, including refractories
- Erosion- and corrosion-resistant materials
- Welding
- *Databases and modeling*
- *Environmentally conscious treatments*
- *Drying and pressing*
- *Databases and modeling*
- *Sensor materials*
- *Adhesives*
- *Waste and by-product treatment, extraction, and use*

Agriculture
- Separation technologies
- *Materials for harvesting equipment*
- *Materials for new reactors and fermentation*
- *Materials for biocatalysis*
- *Standards & product quality*

Mining
- Wear-resistant materials
- Physical separation
- *Process modeling and simulation*
- *Mineral characterization*
- *Membrane systems*
- *By-product characterization, recycling, and use*

Identification of IMF Multiple Industry and Core Research Areas

- **IMF multiple-industry research areas are the common research priorities derived from the individual IOF performance target–research need matrices**

- **IMF core research areas are those in which advances and accomplishments will support and feed the common research priorities**

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IMF Multiple-Industry R&D Priorities

Industries of the future

Research priority areas	Aluminum	Glass	Steel	Metal casting	Chemicals	Petroleum	Forest products	Agriculture	Mining
Corr-, eros-, wear-resist materials	■	■	■	■	■	■	■	■	■
Databases and modeling	■	■	■	■	■	■	■		■
High-temp. mats. & Refractory	■	■	■	■	■		■		
Membranes & phys. Separations					■	■	■	■	■
Joining & welding	■		■	■	■		■		
Coatings		■	■	■	■	■	■		
Waste & byproduct treat, use				■			■		■
Casting, tools & dies	■		■	■					

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IMF Core Research Areas

- **Database development**

- **High temperature properties**

- **Wear, erosion, and corrosion resistance**

- **Processing-properties relationships**

- **Modeling of processing, forming, and deposition**

- **Separation methods**

- **Materials for sensors**

- **Materials chemistry**

- **Surfaces, interfaces, and joining**

Provide opportunities for new materials and processing technologies to achieve IOF performance targets

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IMF Multiple Crosscutting Programs and Supporting-Industry R&D Priorities

Programs and industries

Research priority areas

	Sensors	Combustion	Heat Treating	Welding and Joining	Forging
Sensor Materials					
Testing and Standards					
Corr./Eros./Wear-Resistant Mats.	■			■	■
Databases and Modeling	■	■	■	■	■
High-Temp. Mats. and Refractories	■	■	■	■	
Membranes and Physical Separations	■	■			
Waste and Byproduct Treat/Use	■	■	■		

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Next Steps

- **Describe materials performance goals and the technical challenges to achieving them, as well as the benefits to the Industries of the Future.**

- **Prioritize IMF research activities to achieve the materials performance goals; emphasize filling the gaps between basic research programs and the OIT industry teams.**

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